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VITALISM.

THERE are certain undying questions which periodically recur in varying forms at successive stages in the advance of knowledge. And when these are critically examined they will generally be found to contain a metaphysical or noumenal element. Such a question is that which falls under the head of Vitalism. Is the conception of Vital Force valid, and is it necessary for the comprehension of the phenomena of organic life? This is the question I propose to discuss in the light of principles already considered. It will probably conduce to clearness if the question is distributed thus: Is Vital Force a valid and necessary conception in the sphere of metaphysics? Has it any *locus standi* in the sphere of science?

A reminder as to the distinction already drawn between science and metaphysics may here be necessary. Both deal with causation; both offer explanations. But whereas the explanations of science refer particular events to the generalisations within which they are comprised (thus the fall of a stone to the earth is referred to the generalised statement of universal gravitation); and whereas they deal with causation in terms of antecedence and sequence, the facts being accepted as data; the explanations of metaphysics offer an answer to the question: Why are the facts such as we find them to be? They deal with causation in terms of noumenal origin or *raison d'être.* The science of dynamics tells us that, given such and such nature and distribution of the parts of a material system, such and such movements or states of strain do as a matter of fact occur. If we ask why such movements or strains occur under these circumstances, metaphysics replies that Force is the noumenal Cause of motion or of strain. It is true that at the beginning of treatises on the science of dynamics there is usually a reference to Force as the Cause of motion. But this is merely a pious tribute to metaphysics, like grace before meat, and has no influence on either the quality of the dinner or its subsequent digestion. Of such a nature is Vital Force. It is a perfectly legitimate metaphysical conception of the noumenal Cause of certain observed phenomena, and should take its place alongside Gravitative Force, Chemical Force, Crystalline Force and the rest of the stalwart metaphysical grenadiers.

It is in large degree because, when Vitalism is the topic of discussion, the disputants on each side fail to distinguish the metaphysical from the scientific elements of the question, that we seem to be as far from a satisfactory solution of the problem as were our fathers a generation ago. Only when the distinction is adequately realised will the combatants be prepared to confess that the battle is drawn, each side holding unconquered an impregnable fortress—the shattering of certain weak outworks, which should never have been occupied, serving only to show the real strength of the central position of either contending host.

It is unnecessary to enter at any length into the past history of the subject. Sufficient unto the generation are the conditions under which its problems must be discussed. Of old, before the forces of science had girt their strength about them, Vitalism held the field in easy if somewhat lax possession. Then came a period of organised attack. Chemistry and molecular physics had formulated and extended their generalisations and began to urge that the problems of physiology were problems of chemistry and physics—nothing more. There was no vital remainder. Taking their stand on the conservation of energy, they contended that the conception of Vital Force involved the appearance of energy without physical or chemical antecedents. This carried conviction among some of our leading physiologists. Prof. Burdon Sanderson wrote: "The proof of the non-existence of a special 'vital force' lies in the demonstration of the adequacy of the known sources of energy in the organism to account for the actual day by day expenditure of heat and work." But an answer in due course came from the vitalists. It was pointed out that the application of a force to a moving body at right angles to its course, alters the direction of motion without affecting its amount. The energy remains unchanged. Of such a directive character, it is sometimes urged, may be the application of vital force without presenting any phenomena contradictory of the generalisation that, in the operations of nature, energy is nowhere either destroyed or created.

So long as the metaphysical conceptions of Force are carelessly commingled with the generalisations of dynamics as a science, this line of argument may appear to possess a cogency which is in truth fictitious. But what is the basal law of dynamics? That every movement of a part in any material system and every state of strain therein, has, as its antecedent, the assignable nature and distribution of the constituent parts in that system. This is a generalised statement of dynamic fact which quietly ignores (though it does not deny) the existence of Force as the noumenal cause of motion. Granting therefore that a vital force is conceivable which alters the direction of motion without producing any change in the amount of energy, the question still remains: Is the movement so produced in accordance with, or is it contradictory to, the basal law of dynamics? For the change of direction of motion is itself a motion, though it be unaccompanied by any increase or diminution of energy. If therefore the motion in question is the outcome of the nature and distribution of the constituent parts in a material system it is a natural movement co-ordinate with other physical movements, and Prof. Burdon Sanderson's contention is in essence valid, as a protest against supernaturalism, though it is incompletely stated; if on the other hand the motion is not such an outcome, then, though the conservation of energy may still hold its ground, what I have termed the basal law of dynamics cannot. There are movements of material particles which are outside this generalisation. It is questionable, however, whether there are many vitalists of scientific training who would care to contend for the truth of this conclusion.

It may be said that I have here quietly ignored certain essential features in any dynamical configuration—namely, the nature of the forces (gravitative, crystalline, chemical, electrical, and so forth) at work within the given system. But from the point of view of science the attractions or repulsions attributed to these forces are merely data to be accepted and stated as simple facts of observation. They are the outcome of the nature and distribution of the parts of the system—including under the head "nature and distribution" the totality of the antecedent conditions. No doubt the antecedent conditions are different according as we place a piece of cork or a piece of sodium on the surface of water. In the one case certain chemical attractions have to be taken into account which in the other case are absent. These form part of the dynamical data without which the problem is insoluble. Science accepts these data as facts in the phenomenal chain of antecedence and sequence. Metaphysics attempts to account for the facts by the conception of Chemical Force. The chemist, as man of science, says: Give me the facts of chemical dynamics and I will comprise them under broad generalisations. The Force, for what it is worth, may be given to that poor beggar of a metaphysician who sings his doleful ditty in the street.

At the same time it should be noticed that we do here open up an obviously important issue. No one has yet been able to show how certain observed modes of attraction can be developed out of others. No one has been able to suggest how, for example, the specific mode of attraction we call cohesion can originate from that which we call gravitation. All that we can say is that, amid all the varied modes of attraction, the sum of energy remains constant. A candid and impartial inquiry into the facts enables us to realise that, under these or those assignable conditions, new modes of attraction supervene—modes which, with our present knowledge, no one could have foretold, since in science it must not infrequently suffice to be wise after the event.

These facts are too often forgotten or overlooked by those who attempt a merely mechanical interpretation of phenomena. It appears to be undeniable that when oxygen and hydrogen combine to form water, or when aqueous vapor in the atmosphere condenses, under these conditions to form rain-drops, and under those to form crystalline snow-flakes, new modes of attraction are manifested for our study and new properties in the products for our investigation. Metaphysically regarded, these are new manifestations of Force, the underlying Cause of attraction. And if by the doctrine of Vitalism no more is implied than this—that, when organic matter first came into being, new modes of attraction and new properties appeared in the field of phenomena, few biologists, I conceive, would hesitate to acknowledge themselves Vitalists to the core. Who is prepared to assert that the molecular changes involved in the attraction and coalescence of the male and female pronuclei, or the rhythmic pulsation of the contractile vesicle in amœba, or the fission of the lowest protozoan animalcule, is anywhere foreshadowed in the inorganic sphere? It is questionable whether the absorption of fluid by any living membrane is a matter of mere osmosis. And though not a few organic products have been artificially manufactured in the laboratory, we seem as far as ever from simulating the synthesis of the digestive secretions. If Vitalism have such facts as these in view it need send forth no missionaries to convert biologists to the true faith. And if Vital Force mean the underlying Cause of such phenomena it may be as freely admitted as Gravitative Force or that which underlies the observed facts of cohesion.

But the champions of Vitalism mean something more than this—or so it appears from the language they are wont to employ. They make no parade of the mystery of gravitation; they do not plead with us to regard chemical attraction as something outside the recognised order of nature; they do not press upon us the conclusion that when the first doubly-oblique crystal came into being, a directive force was brought into play—a force of precisely the same character as that which enables the sculptor by the exercise of his Will to carve from the shapeless marble a Venus of Milo; they do not write books and magazine articles to convince us that the natural origin of the lightning flash is inconceivable. But of this kind are the attitudes they too often assume when the phenomena of life are in question. The origin of life is a mystery; it marked a new epoch in Creation; its phenomena demand the belief in a quasi-intelligent directive force; its natural genesis is not only unproven but beyond the limits of human conception. Against such a doctrine of Vitalism an energetic protest should be entered, both by science and by a metaphysics which (if such a thing be possible) preserves its sanity.

In his recent presidential address before the chemical section of the British Association on the occasion of its meeting in Bristol (1898), Professor Japp urged the claims of Vitalism from the point of view occupied a generation ago by Pasteur. His presentation of the subject was admirably lucid, and his arguments ably marshalled. It is worth while to examine the position taken up by so well-accredited an advocate.

The salient facts and conclusions are briefly as follows: When polarised light passes through certain substances the plane of polarisation is rotated—in some cases to the right in others to the left. "The effect is as if the ray had been forced through a twisted medium—a medium with a right-handed or a left-handed twist—and had itself received a twist in the process; and the amount of rotation will depend (1) upon the degree of twist in the medium (that is, on the rotatory power of the substance), and (2) upon the thickness of the stratum of the substance through which the ray passes; just as the angle through which a bullet turns, in passing from the breech to the muzzle of a rifle, will depend upon the degree of twist in the rifling and the length of the barrel."

Now these optically active substances, as they are termed, may be divided into two classes. Some, like quartz, produce rotation only in the crystallised state; the dissolved or fused substances are inactive. Others, like sugar, are optically active and produce rotation, not only in the crystallised state but also in the liquid state or in solution. In the former case the molecules of the substance have no twisted structure, but they unite to form crystals having such a structure. As Pasteur expressed it, we may build up a spiral staircase—an asymmetric figure—from symmetric bricks; when the staircase is again resolved into its component bricks, the asymmetry disappears. In the case however of compounds which, like sugar, are optically active in the liquid state, the twisted structure must belong to the molecules themselves. Such molecular asymmetry is, so far as we know, only found in organic substances; and their production is one of the distinguishing characteristics of living matter.

But there are sundry substances, such as racemic acid, which, though they are inactive, owe their inactivity to the equilibrium of opposite rotations. When a solution of one of the salts of this acid is evaporated, beautiful hemihedral crystals, belonging to the rhombic system, are obtained. Such hemihedral crystals are asymmetrical. But Pasteur found that they are not all alike. Half of them are lop-sided in one direction; the other half in the other direction. They answer to each other as our right hand answers to the left; each is the mirror image of the other. Such pairs are termed enantiomorphs. Furthermore, if all the right-handed crystals, and all the left-handed ones, be picked out and dissolved to make two solutions, each solution will be optically active, the one with a left-handed, the other with a right-handed twist. But in all other respects they are alike. Their salts have the same solubility in symmetric media, the same specific gravity, and so forth. It is assumed, therefore, that in the original solution right and left-handed molecules exist in equal proportions, and that their equal and opposite optical activities balance each other so as to give apparent inactivity.

If now such a mould as *Penicillium* be grown in a solution of the ammonium salt of racemic acid, fermentation takes place; and the solution, originally inactive, becomes optically active. The living substance is able to select all the optically right-handed moiety of the solution, leaving the left-handed moiety intact; and from this the appropriate lop-sided crystals, of one type only, may be readily obtained. It is urged, therefore, that there are two modes, and only two modes, in which the complementary types of molecules commingled in a racemic or analogous solution can be separated,—either by the selective action of a rational being who has this end in view, or by the action of living organic matter or its products. The separation cannot conceivably be effected through the chance play of symmetric forces. The absolute origin of one-sided asymmetry is a mystery as profound as that of life itself. "No fortuitous concourse of atoms, even with all eternity to clash and combine in," says Professor Japp, "could compass this feat of the formation of the first optically active organic compound." "I see no escape from the conclusion," he adds, "that, at the moment when first life arose, a directive force came into play,—a force of precisely the same character as that which enables the intelligent operator, by the exercise of his Will, to select one crystallised enantiomorph and reject its asymmetric opposite."

Such is one of the latest pronouncements of Vitalism. Let us critically consider the evidence; but before doing so let us endeavor to be quite clear on certain preliminary matters of broad and general application.

Are we to regard the argument as special and applicable to Vitalism only; or are we to look upon it as general and applicable also to Chemism, Crystallism, and an indefinite number of other isms? Are we to look upon the directive force, analogous to that exercised by an intelligent operator, which, we are told, was called into play at the moment when first life arose, as something essentially different in its nature from anything which is found in the inorganic world? Is it alone characterised by its directiveness; or is such directiveness exercised elsewhere in nature in different modes and under different conditions? Again, is the inconceivability of the origin of asymmetry from "the chance play of symmetric forces," special to the problems suggested by living matter, or is it only a special example of an inconceivability which faces us in other regions of our extended survey of nature? Once more, is genesis by fortuitous concourse of atoms (a conception in itself bewildering in its irrationality) unsatisfactory where protoplasm is concerned, though satisfactory for inorganic products; or is it to be regarded as intrinsically absurd as a way of accounting for anything in an orderly world of phenomena? The answer to these questions is really of fundamental importance. It makes all the difference whether we are discussing something which is distinctive of life and its origin—distinctive not only in its mode of operation but in its essential character—or whether we are discussing principles which are common to natural phenomena, including those of organic nature, in many of their varying phases. A belief in the former, as implying a supernatural hiatus between the inorganic and the organic, is to be regarded as unphilosophical and misleading; the acceptance of the latter is the logical outcome of a survey of phenomena and the teaching they afford.

I have no wish to imply that Professor Japp in his address intended to limit the application of a "directive force" to the phenomena of life. But I am quite certain that many of those who read that address will read it in this sense. And it is rather to them than to him that I would address the remarks that follow. It will serve to put the matter in a clearer light if we state the question in a somewhat concrete form, and ask: Is there anything in the phenomena of life which differs, not merely in mode of operation but in principle, from what may be discovered in the phenomena of crystallisation? It is convenient to select crystallisation because here also we are presented with certain optical effects.

First let us consider the building up of crystalline forms. All known crystals may be classified in six groups or systems, and their forms being solid geometrical figures, the relations of the faces to each other may be expressed geometrically. To lessen confusion, let us limit our attention to three readily obtainable crystalline forms. If we allow a solution of aluminium-potassium sulphate to evaporate slowly, large octohedral crystals of alum will be produced. Each is symmetrical in all crystallographic respects. Each has six points or solid angles, and it matters not which of these points is placed uppermost. Imaginary straight lines drawn from point to point within the crystal are spoken of as the axes. There are three such axes, all at right angles, and all of equal length; and any face of the crystal cuts three of these axes symmetrically at equal distances from the centre of the figure. Next allow a solution of sulphur in carbon bisulphide to evaporate slowly. Rhombic crystals of sulphur will be obtained. There are six solid angles as before, but they are not symmetrical in the same sense. They answer to each other in opposite pairs, but they are not all alike. There are three axes, and all are at right angles, but they are all of different lengths. Any face of the crystal cuts three of them, but at unequal distances from the centre of the figure. Whether we take large crystals or small crystals, these distances are proportional; and the angle between any similar pair of faces remains constant. Thirdly, let a solution of sulphate of copper evaporate and give rise to crystals of blue vitriol. The geometric figure is far less simple and symmetrical. At first it may seem that all the faces are dissimilar. But closer study shows that there are pairs of faces, situate opposite and parallel to each other, which are alike; but no one of these pairs is like other pairs. There are still three axes; but not only are they of different lengths, but no two are at right angles to each other. They are inclined at different angles; hence they are said to belong to the doubly-oblique or triclinic system.

Such, stripped as far as possible of technical details, are the observed facts with regard to these three kinds of crystalline architecture. The alum, the sulphur, and the blue vitriol, present us with three types of crystal; but the crystals of each substance remain true to their several types. There is no theory about this; it is merely a statement of facts of observation; for the reference to supposed axes is merely for convenience of geometrical expression. Apart from crystallisation there is nothing quite like this method of building in nature. To say that such crystals result from the fortuitous concourse of molecules is nothing less than grotesque. But if it is not a fortuitous concourse of molecules, it must be a directed or (to use a better word) determinate concourse. How then does the determinism of the crystal, each after his kind, arise? A science which has learnt the grace of modesty can only reply: We do not know. To drop into the colloquial, if not very elegant, prose of Dr. Watts's hymn, one can but say: For 'tis their nature to. Such are the facts. We believe that they are the visible expression of certain attractions or repulsions; and if we like to dip into metaphysics we may add that the cause of these attractions is crystalline force. Surely we may say here with just as much (or as little) cogency as may be said with regard to the phenomena of life, that when the first crystal arose, a directive force came into play—a force of precisely the same character as that which enables an intelligent operator, by the exercise of his will, to build up the model of a crystal.

If it be urged, with an almost desperate appeal to metaphysics, that the potentiality of assuming the crystalline form existed in certain kinds of matter ere ever a crystal was formed, it is difficult to see wherein this assertion differs from Tyndall's celebrated poetic outburst, when he proclaimed that he could "discern in that matter which we, in our ignorance of its latent powers, have hitherto covered with opprobrium, the promise and potency of all terrestrial life." Such appeals to potentialities and potencies do not really help us in any appreciable degree. To say that crystalline polarity is due to the polarity of the molecules merely shifts the question back a step; for we must still ask: How did this molecular polarity arise? At some stage, sooner or later, we are brought face to face with the final answer of science; that such is the observed or inferred constitution of nature. The reference to potency and potentiality is merely a somewhat pompous mode of stating that what does occur under certain conditions can occur under these conditions.

We may now pass to the brief consideration of certain optical effects which are observable in our three crystals. If a number of sections be cut, so as to give us flat plates, some being cut from the crystal in one direction and others in other directions, that is to say, making various angles with the geometrical axes; and if these be placed on a piece of white paper over a minute inkspot thereon; then it will be found that, in the case of the sections or slices of alum, they are all alike in exercising no peculiar influence on the rays of light passing through them from the inkspot. Through every one of them a single image of the inkspot will be seen. There is no double refraction. But in the case of all, or nearly all, of the plates of sulphur or blue vitriol (in all save those which are cut at right angles to two imaginary lines termed the optic axes) two images of the inkspot will be seen, or might be seen if the plates were thick enough and sufficiently transparent.

The slices exhibit the phenomena of double refraction. The rays of light which pass through the crystalline plates are divided into two groups. And by appropriate means it can be shown, first that the two groups pass through the plate at different rates, one group being more retarded than the other; and secondly that each group consists of polarised rays, or rays the vibrations of which are all parallel to one plane. In the two groups the planes of polarisation are at right angles; thus if we call the one *N* and *S* the other will be *E* and *W*.

It is clear therefore that there is something about the crystalline plates of sulphur and blue vitriol (and these differ from each other in ways which need not be entered into) that produces certain peculiar optical effects. Now it is found that a plate of glass behaves just like a plate of alum and produces no double refraction. But if the plate be unequally heated, or if it be subjected to a mechanical twist, double refraction is induced. Since therefore this optical effect may be artificially induced by differential strain it is reasonable to suppose that the plates of sulphur and blue vitriol are, under natural conditions, in a state of differential strain, of which double refraction is the optical expression. And since solutions of sulphur and blue vitriol show no double refraction it is reasonable to suppose (on the assumption that the molecules themselves undergo no change during solution) that the strain is produced by the interactions of the molecules when they assume the crystallised state. So that, if we are to use the analogy of the intelligent operator, not only does he build up the crystals in definite geometric forms, each true to its system type and to its generic and specific type within the system, but he introduces the dynamic element of differential strain itself true to its system type, and to its generic and specific type within the system. And these differential strains are not manifested until crystal forms arise in the course of what we believe to be a natural process of evolution.

There is one more lesson which the crystal has to teach. It exercises a further differential influence which is markedly selective in its nature. If, for example, we take a plate of the mineral tourmaline, cut parallel to the principle geometrical axis, the light within the crystal is divided into two groups of vibrations polarised in opposite planes. But only one group passes through the crystal and reaches the eye; the other is quenched within the plate. So that the crystallised substance "selects" one set of polarised rays for transmission and the other set for extinction.

Some crystals of quartz exhibit small asymmetric faces. The common form of this mineral, with a hexagonal prism capped by a hexagonal pyramid is a familiar object. But sometimes the solid angles between the prism and the pyramid are asymmetrically bevelled off to form these tetartohedral faces. And these faces are situated in some cases to the right and in others to the left. The complementary forms are thus mirror-images of each other. They answer to each other as the right hand answers to the left. They are enantiomorphs. And each has the property of rotating the rays of plane-polarised light to the right or to the left according to the position of the asymmetric faces. These effects may be attributed to differential strains; and since they are only observed in the crystalline condition of quartz, it is held (on the assumption that fusion does not alter the molecules) that the strains are inter-molecular (or between the molecules) and not intra-molecular (or within the molecules). However they arise, there they are, exhibiting a yet further differential effect on the ray of light. We do not know whether the right-handed or the left-handed forms predominate in nature; or whether the numbers, or the joint mass, of the one exactly balance those of the other.

Thus we lead up to the enantiomorphs in crystalline substances of organic origin. As Professor Japp points out, the fact that an optical twist is produced, not only in the crystalline condition but also in solutions, leads us to suppose that the differential strain is intra-molecular and not inter-molecular. His thesis is that, since the enantiomorphs or mirror-types are produced in complementary pairs (right-handed and left-handed rotation being equal and opposite in amount) the selection of either for predominance is "absolutely inconceivable" under the play of symmetric forces. But the teaching of the crystal has made us familiar with the fact that a mode of optical "selection," if not this mode, occurs under the play of natural forces. For the tourmaline plate selects vibrations in one plane for transmission and vibrations in the opposite plane for extinction. And the teaching of the solar system with its predominant anti-clockwise rotation, has made us familiar with the fact that from the play of (presumably) symmetric forces an asymmetric resultant may arise.

Let us however look at the actual facts. We find that from a racemic solution enantiomorphous, mirror-type crystals, up to a size of, say, half an inch, may be produced, some right-handed, others left-handed, in equal amounts. What gives rise to the observed preponderance of right-handed molecules in the one crystal and of left-handed molecules in the other? Must we not reply either that there is a selective influence at work at a stage prior to that postulated, or at any rate emphasised, by Professor Japp; or that chance gave an initial preponderance, here of the one and there of the other, and thus formed nuclei for the further segregation of like to like?* Either answer is difficult to square with Professor Japp's essentially vitalistic conception. In any case crystals half an inch or so in diameter, some right-handed and others left-handed, are actually formed. And it is scarcely an extravagant supposition, one certainly not beyond the bounds of conceivability, that, given a finite number of such crystals, a quite indiscriminate mode of destruction might reduce this finite number to one, or to a small uneven number, and thus leave a group with a preponderance of one or the other type of molecule.

Now granting that the first formed organic molecules were possessed of equal and opposite rotatory powers, is there anything inconceivable in the supposition that when these segregated into units of protoplasm, some of these units were right-handed, and others left-handed, in equal amounts? Nay rather, may we not apply the lesson of the racemic crystals here, and urge that the observed segregation in the crystals renders it probable that a similar segregation occurred in the units of protoplasm? And the analogy

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[1] Prof. Karl Pearson has, since this was written, adopted a similar line of argument. See *Nature*. Nov. 10th, 1898, p. 30.

in the two cases is strengthened when we remember that the rotatory property is not the outcome of the crystallised condition but is (as solution is held to show), of intra-molecular origin. But if this be so the units of protoplasm, the initial starting-points of life (starting-points with some of which existing life is continuous), were individually asymmetric, though in the aggregate of distinct individuals their asymmetry was complementary. And this is just what is denied to be conceivable under natural conditions ! So far from being inconceivable it is precisely that which known facts render inherently probable.

Lastly, if we grant that, when protoplasm first came into being, asymmetric molecules had their initial genesis, is there anything here different in principle from that with which the study of inorganic nature has already made us familiar? Such asymmetry is presumably due to differential strain between the atoms, or between subordinate groups of atoms, within the molecule. But the lesson of the crystal tells that certain modes of differential strain, elsewhere unknown in nature, arise under appropriate conditions, and should prepare us to learn, in the succeeding organic lesson, that other modes of differential strain may arise under other conditions. When we remember of what an extraordinarily complex group the molecule of protoplasm in all probability consists, it seems hazardous to assert that circular polarisation cannot be its natural prerogative, just as plane polarisation is a natural property of the much simpler group of molecules in the crystal of sulphur or blue vitriol, especially when we find crystals of quartz and other inorganic substances, possessed of circular polarisation.

And so, after (it is feared) much technicality of discussion,—technicality which can scarcely be avoided if the discussion is to be adequate,—we reach the conclusion that, in so far as the hypothesis of Vitalism merely directs our attention to those new modes of attraction and of intra-molecular strain, together with other concomitant properties, the occurrence of which in living matter is observed or inferred, it is doing good service. But when it asserts that any natural connexion or analogy between these properties and those found elsewhere in nature is inconceivable ; when it hints at modes of action not in accordance with the conservation of momentum and what has been described as the basal law of dynamics; when it invokes the *special* intervention of a directive force, analogous to that exercised by an intelligent operator; then it is not doing good service and must be arraigned at the bar of science and metaphysics. And if vital force is to be placed alongside crystal force, as the noumenal cause of certain observed or inferred attractions and repulsions, we can discuss its validity without doing violence to our conceptions of the universe as a rational whole; but if it is to be regarded, not as immanent and acting within the material system, but as external and introduced from beyond the system, then we must regard it, not as a friend to be welcomed, but as a foe whose insidious attacks must be repulsed lest it hold our weaker brethren in bondage.

Notwithstanding some appearances to the contrary, I venture to hope that the conclusion to which we have here been led is substantially in accord with that which Mr. Herbert Spencer reaches in the new edition of his *Principles of Biology*. He there contends for a principle of activity, elsewhere termed a special kind of energy, which constitutes the essential element in our conception of life. He urges that this is conceivable neither as something superadded from without, nor as something inherent in organic matter. And he regards it as due to that Ultimate Reality which underlies this manifestation as it underlies all other manifestations. He reminds us that the actions of that which the ignorant contemptuously call brute matter, cannot in the last resort be understood in their genesis. And in concluding that, on the one hand, we find it impossible to think of life as imported into the unit of protoplasm from without, so also, on the other hand, do we find it impossible to conceive it as emerging from the co-operation of the components; he attributes this to the fact, that while phenomena are accessible to thought, the implied noumenon is inaccessible; that only the manifestations come within the range of our intelligence, while that which is manifested lies beyond it.

We will not stay to inquire how it comes about that the existence of a noumenon inaccessible to thought can be implied. Mr.

Spencer's meaning, I take it, here and elsewhere, is, that though noumenal existence is implied, and so far comes into the field of thought, its nature is unknowable,—a conclusion which need not here be discussed. The essential point seems to be that new modes of manifestation imply new modes of activity in the noumenal cause; and this is just the conclusion to which our own discussion has led up. At the same time there are some statements of Mr. Spencer which may well seem to indicate an interpretation different from that which I have endeavored to present, and more akin to that against which I have been contending.

On the first page of the *Principles of Biology* we are told: "The properties of substances, though destroyed to sense by combination, are not destroyed in reality. It follows from the persistence of force, that the properties of a compound are the resultants of the properties of its components,—resultants in which the properties of the components are severally in full action, though mutually obscured." And in the discussion of the dynamic element in life we read: "The processes which go on in living things are incomprehensible as results of any physical actions known to us;" and again: "We find it impossible to conceive life as emerging from the co-operation of the components of protoplasm." Now, if these statements be taken to imply that in the organic world an incomprehensible principle of activity comes into operation different, not only in its mode of manifestation, but in its essential nature, from anything to be found in the inorganic world, (and this at first sight does seem to be implied,) then must Mr. Spencer be looked upon as a champion of Vitalism in its unsatisfactory form. I cannot believe that this is the true reading of Mr. Spencer's statements. It does not accord with the broader contention that the Ultimate Reality behind this manifestation, *as behind all other manifestations*, transcends conception. It must be remembered that Mr. Spencer has (to our great loss) been forced to omit from his System of Philosophy the volumes which should have dealt with inorganic evolution. May we not, from the general tenor of his thought from such statements as are found in the "letter to the Editor of *The North American Review*," and from other passages of his works,—may we not from these conclude that, had the inorganic volumes been written, it would have been shown that in the genesis of the crystal too a new manifestation of Force came into play? And may we not fairly place parallel to each other the following assertions: first, that we are obliged to confess that life in its essence cannot be conceived in physico-chemical terms,—one which Mr. Spencer does make; and, secondly, that we must similarly confess that crystallisation in its essence cannot be conceived in gravitative terms,—one which Mr. Spencer does not make, but which is, I conceive, nowise contradictory of anything that he has written?

But perhaps I have no right to fly the commodore's flag at the masthead of my own craft; and, in any case, no impertinence to a superior officer is thereby intended. The conclusions reached must be taken for what they are worth; no banner of authority can render them better or worse. Those conclusions are, that, if by Vitalism we give expression to the fact that living matter has certain distinctive properties, it may be freely accepted; but that if by it we imply that these properties neither are nor can be the outcome of evolution, it should be politely rejected; and further that, if by Vital Force we mean the noumenal Cause of the special modes of molecular motion that characterise protoplasm, its metaphysical validity may be acknowledged, so long as it is regarded as immanent in the dynamical system and not interpolated from without in a manner unknown throughout the rest of the wide realm of nature.

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